Prediction of Aquatic species behavioral modification in response to Anthropogenic Stressors using Arduino

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Abstract:
Human actions continue to remain a significant and ongoing threat to underwater environments, highlighting the critical need for a comprehensive understanding of how these stressors impact marine life. In order to address this pressing issue, we have embarked on an ambitious project that harnesses the capabilities of Arduino technology to develop an advanced monitoring system. The primary aim of this system is to anticipate, track, and gain a deep understanding of the behavioral responses of aquatic species to stressors caused by human activities. To obtain real-time data on stressor levels and behavioral changes in aquatic organisms, we deploy a wide range of sensors that are compatible with Arduino technology. These sensors include monitors specifically designed to measure the quality of the water, temperature sensors that detect fluctuations in temperature, and detectors adept at identifying motion. By strategically placing these sensors in various aquatic environments, we are able to gather valuable data on stressor levels and observe the adaptive behaviors that aquatic species undergo. The key sensors incorporated in our monitoring system encompass pH sensors, temperature sensors, sound sensors, and turbidity sensors. Through a

thorough analysis of the data collected by these sensors, we can determine the concentration of dissolved oxygen in the water, contributing to a comprehensive understanding of the ecosystem's dynamics. The insights gained from our monitoring system provide valuable information regarding the impact of human activities on aquatic ecosystems. Fluctuations in temperature and sound levels can be observed, potentially leading to the identification of correlations between these factors. Additionally, distinct patterns in sound levels throughout the day and across seasons become apparent, suggesting the existence of seasonal variations in human activities that can influence aquatic ecosystems. Based on our findings, it becomes increasingly clear that this project has the potential to bridge existing knowledge gaps concerning the relationship between human activities and their consequences on aquatic ecosystems. The conclusions derived from our project highlight the urgent need to address stressors caused by human activities in order to effectively preserve these fragile ecosystems. To support our research, we have extensively referenced various studies on water quality monitoring systems, the utilization of Arduino technology in water quality assessment, and research on fish reactions to disturbances caused by human activities. By using the available and pre-existing knowledge, our project significantly contributes to the field of environmental conservation by providing valuable insights into the intricate relationship between stressors induced by human activities and the behavior of aquatic species.

Introduction:

Life in the underwater world faces serious challenges due to human activities. Pollution, habitat destruction, and changes in water conditions are just a few of the problems impacting marine creatures and their way of life. These changes are like puzzle pieces that, when put together, help us unravel the complex story of underwater ecosystems. Understanding this story is crucial for protecting these environments and managing them wisely.

Realizing the urgency of this mission, our research steps into the limelight, using Arduino technology as our guiding light. Arduino, known for its adaptability and user-friendly nature, becomes the beating heart of our efforts to predict, monitor, and comprehend how aquatic species respond to the stress caused by humans. This research isn't just about technicalities; it's a significant move towards syncing up human activities with the delicate rhythms of aquatic life. As human actions increase, the toll on underwater environments becomes more and more apparent.Pollution, whether from factories or farms, brings harmful substances into the water, posing immediate threats to the creatures living there. Urbanization and deforestation, leading to habitat loss, upset the delicate balance, putting aquatic species at risk of losing their homes and essential places for breeding and feeding.

One major consequence of these issues is the changing quality and temperature of the water, which can affect the health and behavior of aquatic organisms. Grasping these challenges requires a broad and collaborative approach. Traditional studies alone aren't enough. Our research recognizes the intricate connection between living beings and technological innovation.

Arduino technology, with its open and adaptable design, provides the perfect tools for creating a monitoring system that captures the subtle behaviors of aquatic species in response to human-induced stressors. This project goes beyond just science; it's a thoughtful attempt to blend technology with environmental care. By predicting and observing how aquatic species behave, we aim to understand the language written in their movements, calls, and adaptations when faced with challenges.Through Arduino, we don't just gather data; we turn it into meaningful insights that can guide policies, inspire conservation efforts, and foster a balanced coexistence between humans and the fragile ecosystems we influence. In the upcoming sections, we dive into the details of our approach, the choice of sensors, the setup of our monitoring system, and the analysis of the rich dataset we've collected. Each part adds to the bigger picture of understanding and lessening the impacts of human-induced stress on aquatic ecosystems.

Background:

This project aims to explore the effects of human-induced stressors on aquatic species' behavior by employing Arduino technology. Anthropogenic factors like pollution, habitat alterations, and changes in environmental conditions significantly impact aquatic ecosystems. Through the utilization of Arduino-compatible sensors such as water quality monitors, temperature sensors, and motion detectors, our goal is to develop a monitoring system. This system will enable real- time data collection on stressor levels and behavioral changes in aquatic organisms.

Our primary objective is to establish connections between variations in stressor levels and observable alterations in aquatic species' behavior. This analysis seeks to unravel how these stressors influence the behavioral adaptations of aquatic life.

The project holds significance in enhancing our understanding of the intricate relationship between human-induced stressors and aquatic species' behavior. By leveraging Arduino technology, we aim to predict and comprehend the behavioral modifications of aquatic species, underscoring the urgency of addressing human-induced stressors for the preservation of these invaluable ecosystems.

Problem-Statement:

To propose an Arduino-driven monitoring system to predict and mitigate the impact of anthropogenic stressors on aquatic biodiversity for Sustainable environmental conservation.

Objective of the proposed work:

[8] Anthropogenic stress alters the balance in aquatic ecosystems in various ways. Here, we review the contemporary literature on how alterations in aquatic systems through environmental pollution, invasive species, and [9] hydro morphological changes carry over to Aquatic ecosystems.

We further review the literature to assess the present state of the field and identify gaps in our knowledge. We begin with discussing the factors that determine how an individual responds to a change in the environment and whether the response is adaptive or not.

Methodology:

Curate a suite of Arduino-compatible sensors, including water quality sensors for pH, turbidity, temperature sensors, and sound sensors. These sensors will be strategically deployed in aquatic environments to capture data on stressor levels while simultaneously monitoring the behavioral adaptations of aquatic species.

pH Sensor

Arduino compatible pH sensor which is designed for accurate and reliable pH measurement in industrial processes has been used. It uses a combination of electrodes and sensitive materials to detect and measure the hydrogen ion concentration in a solution, which indicates its pH level. A pH value within a specific range is generally indicative of water quality. For example: pH 6.5-8.5.

Fig-1 pH sensor and it's module

Temperature Sensor

The temperature sensor is a device implemented to measure the temperature of a substance. In this research, we used the DS18B20 model, a thermistor-based temperature sensor, to quantify the temperature of the water. The thermistor is a semiconductor device whose resistance changes with temperature. The change in resistance is used to calculate the temperature of the water.

Types of fishes based on environment	**Ideal temperature**
Freshwater fish	18-24°C (64-75°F)
Tropical fish	24-28°C (75-82°F)
Coldwater fish	10-20°C (50-68°F)

Fig-2 DS18B20 Temperature sensor

Sound Sensor

Sound sensors are devices that can detect and measure sound levels or variations in sound. We used the KY-038 model sound sensor, they often use components like microphones or specialized transducers to convert sound waves into electrical signals that can be analyzed or utilized by electronic systems.

Fig-3 KY-038 sound sensor

Turbidity Sensor

The turbidity sensor works on the principle of light scattering. The sensor emits a beam of light, which is scattered by the suspended particles in the water. The amount of scattered light is measured by the sensor, which is proportional to the turbidity of the water.

Fig-4 Turbidity sensor with module

Calculation of Dissolved Oxygen

The dissolved oxygen concentration is calculated using the temperature, pH, and turbidity values. The calculation is based on the solubility of oxygen in water, which is affected by temperature, pressure, and pH. In this research, the dissolved oxygen concentration is calculated from the output of the sensors.
To calculate the dissolved oxygen concentration (DO) from sensor readings, we can use the following formula:
DO = T * normalized_T +pH * normalized_pH +TUR *normalized_TUR
(or) ***DO = a * e$^{(b*T)}$ * 10$^{(pH - c * TUR)}$,*** (replace a,b,c with calculated calibration values) (or) ***DO = T + round (-0.1 * round (Turbidity)/2) + (0.5 * (pH) + 8),***
(-0.1,0.5 and 8, these values are calculated calibration values for used sensors. This formula has +- 0.4 error)
DO = Dissolved oxygen level in mg/L
T = Temperature of Water (in Celsius, obtained from a temperature sensor and converted to Kelvin)
pH = pH value noted by pH sensor
TUR = Turbidity value by the turbidity sensor

Hardware Implementation

The hardware of the system consists of an Arduino microcontroller, a Temperature sensor (Model: DS18B20), A sound sensor (Model: KY – 038), a Turbidity sensor, a pH sensor (Model: EC5327), a pH sensor module, a 4.7k Ω resistor, a breadboard and jumper wires (M- M, M-F, F-F). Before assembling the sensors, the sensors should be calibrated and each sensor should be checked precisely using some standard techniques like testing the temperature sensor in different temperatures, testing the sound sensor at different decibel levels, etc. The following will explain how to assemble the setup as shown in Fig-5.

- Every sensor has 2 common pins which are ground and power (5V).
- Connect the power and ground from Arduino to the breadboard using jumper wires.
- Temperature sensor: Connect the power and ground to the breadboard and the sensor has one more wire which is a communication wire, connect it directly to the Arduino setup. Temperature cannot take 5V, so connect a 4.7K Ω resistor to the power and communication line in the breadboard.
- Sound sensor: Connect the power and ground pins parallel to the temperature sensor and the sensor has 2 more pins which are analog output and digital output which can be directly connected to Arduino.
- Turbidity sensor: Connect the power and ground pins parallel to the temperature sensor and the sensor has one more pin which is analog and can also be directly connected to the sensor.
- pH sensor: pH sensor cannot be connected directly to Arduino because it does not have the BNC connector for the electrode, so we need a separate module for it, connect the power and ground between the pH module and breadboard using jumper wires parallel to the temperature

senor. Connect the PO directly to the analog pin input in the Arduino and connect the pH electrode to the pH module through the BNC connector.

At last, connect your Arduino to the computer using a USB connector to get the readings.

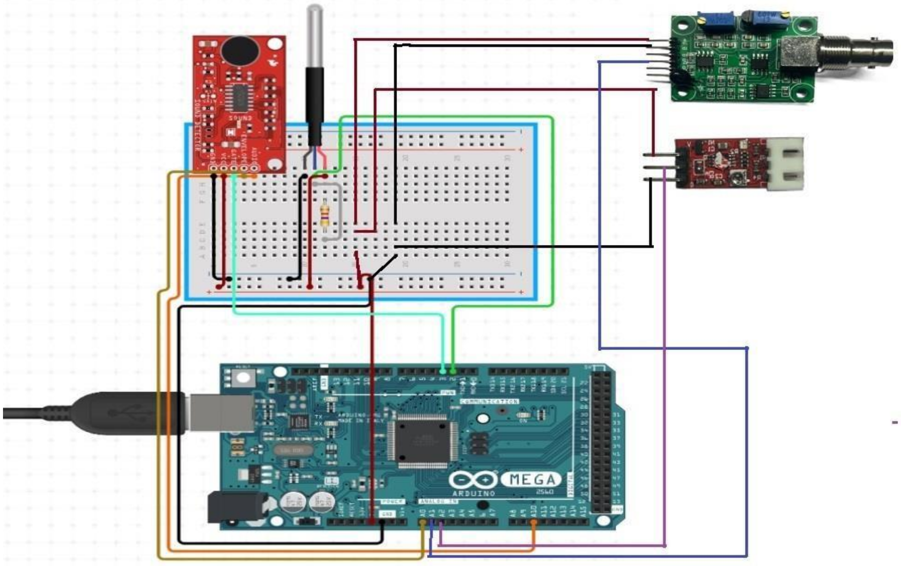

Fig-5- Hardware design of the prototype

Result and Discussion

- Login page:

Fig-6[Login Page]

- Menu Window:

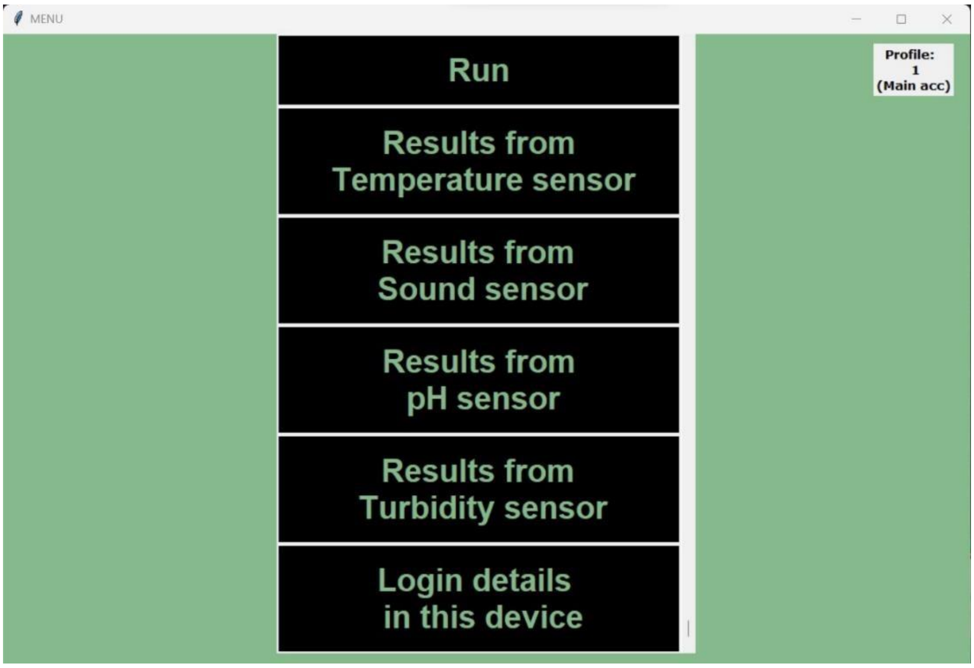

Fig-7 [Menu]

- If we press the Run button, the Output Window shows up [Fig-8].

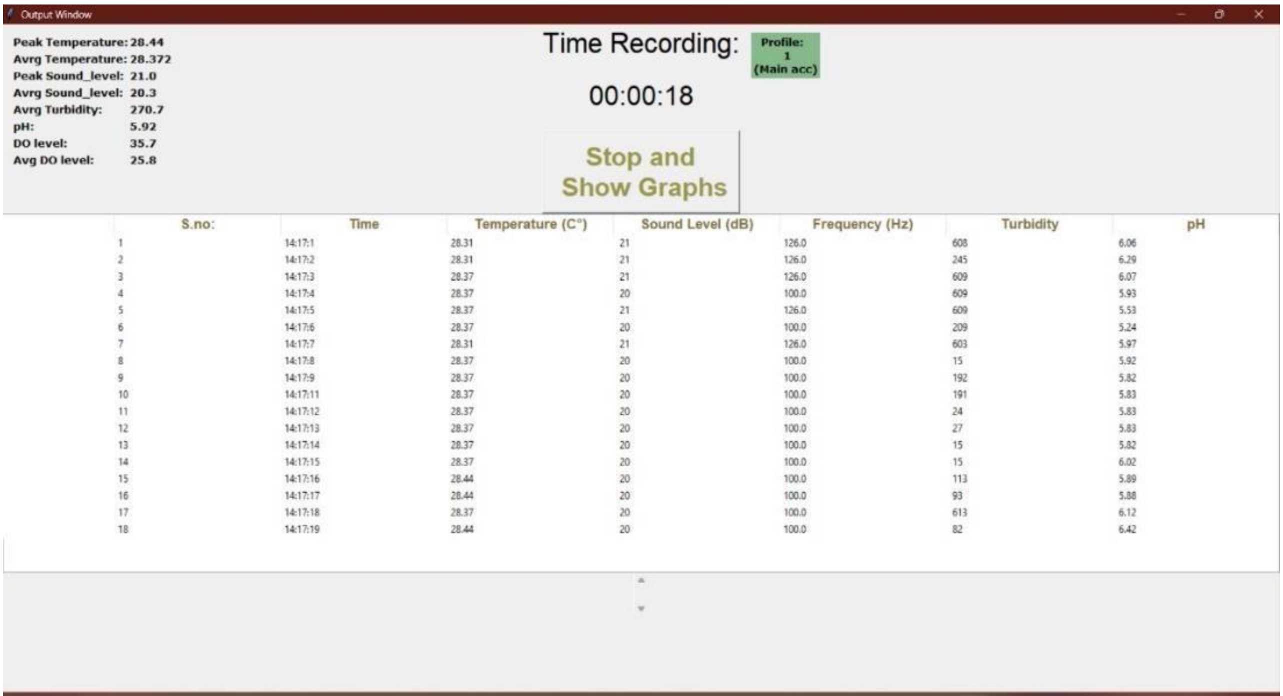

Fig-8 [Output Window]

- After the Output window stops, here we get Graph window [Fig-9]

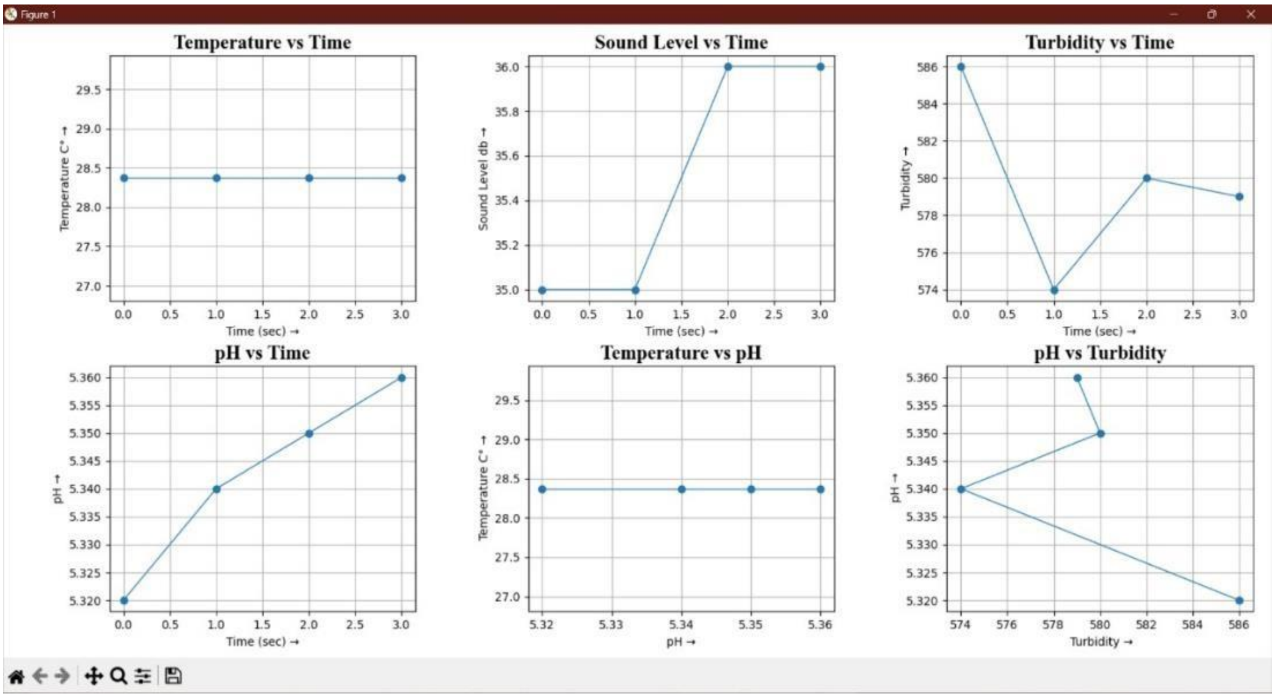

Fig-9[Graph]

Conclusion and Future Scope

The conclusion of our project marks a significant milestone in bridging the intricate relationship between human activities and their impact on aquatic ecosystems. The implementation of Arduino technology has proven to be a pivotal tool in predicting and comprehending the behavioral modifications of aquatic species in response to anthropogenic stressors. Through the deployment of a multi-sensor monitoring system, we have garnered valuable insights into the dynamics of aquatic ecosystems and the effects of human-induced stressors on marine life.

Thi project's results have unveiled compelling observations, particularly in the realms of temperature dynamics and sound level variations. The consistent temperature increases detected suggest potential anthropogenic or climate-related influences on aquatic environments. Furthermore, the correlation between sound levels and temperature during warmer periods indicates a tangible link between human activities and increased sound levels. These findings emphasize the need for further investigation into specific stressors, such as boat traffic or industrial processes, that may be contributing to elevated sound levels. The diurnal and seasonal trends in sound levels have provided additional layers of understanding. Peaks in sound levels during daytime hours and correlations with temperature changes highlight potential seasonal shifts in human activities impacting aquatic ecosystems. This nuanced insight underscores the importance of considering both short-term and long-term patterns in environmental monitoring and conservation efforts.

In conclusion, our project not only enhances the scientific understanding of aquatic ecosystems but also emphasizes the urgency of addressing human-induced stressors for the conservation of these fragile environments. The Arduino-driven monitoring system serves as a practical and accessible tool for ongoing research in this field. As we move forward, the implications of our findings extend into the realm of sustainable environmental conservation. The identified stressor patterns and behavioral adaptations provide a foundation for developing targeted conservation strategies to mitigate the impact of human activities on aquatic biodiversity. The future scope of this project involves expanding the monitoring network to different aquatic environments, conducting long-term studies to capture more nuanced patterns, and integrating machine learning algorithms for predictive analysis. By continually refining our understanding of the complex interplay between anthropogenic stressors and aquatic species behavior, we contribute to the collective effort to safeguard these vital ecosystems for future generations.

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Codes in Appendix

Arduino code:

```
#include <OneWire.h>
#include <DallasTemperature.h>
#define ONE_WIRE_BUS 2

OneWire oneWire(ONE_WIRE_BUS);
DallasTemperature sensors(&oneWire);
int soundSensorPin = A2;

int analogPin = A0;
int pHSensorPin = A1;
void setup() {

  Serial.begin(9600);
  sensors.begin();

}
void loop() {
  sensors.requestTemperatures();

  int Turbidity = analogRead(analogPin);
  float temperature = sensors.getTempCByIndex(0);
  int soundLevel = analogRead(soundSensorPin);
  int pHValue = analogRead(pHSensorPin);

  float voltage = (float)pHValue *  (5/1023.0/2);
  float pH = 3.5*voltage;
  Serial.print(temperature);

  Serial.print(" , ");
  Serial.print(soundLevel);
  Serial.print(" , ");
  Serial.print(Turbidity);
  Serial.print(" , ");
  Serial.println(pH);
  delay(1000);

}
```

Python code:

```
import seriel
import os
import datetime
import random
import threading
from tkinter import *
from matplotlib.backends.backend_tkagg import FigureCanvasTkAgg
matplotlib.use('TkAgg')

import matplotlib.pyplot
as plt td = []

sd = []
fd = []
tid = []
ser = serial.Serial('COM5',
9600) t = open('temp.data',
'a+')

f = open('freq.data', 'a+')
login_db =
{"1": "1”} def
graph():

global dfl
global
td,sd,tid,fd
dfl = False

fig, (ax1, ax2,ax3) = plt.subplots(1,3)
current_datetime = datetime.datetime.now()

filename = "temp_sound"+current_datetime.strftime("%Y-%m-%d_%H-%M-%S")
custom_figure_name = filename

ax1.plot(tid, td,marker='o')
ax1.set_xlabel("Time (sec) →")
ax1.set_ylabel("Temperature C° →")
```

```
ax1.set_title("Temperature vs. Time")
ax2.plot(tid, sd,marker='o')
ax2.set_xlabel("Time (sec) →")
ax2.set_ylabel("Sound Level db →")
ax2.set_title("Sound Level vs. Time")

ax3.plot(fd,tid,marker='*')
ax3.set_xlabel("Time (sec)
→") ax3.set_ylabel("Frequency
Hz →")
ax3.set_title("Frequency vs.
Time") plt.suptitle("Sensor
Data V/S Time") plt.show()

td=[]
sd=[]
tid=[]
output_window =
None def
ot(output_window
):

stop_flag =
threading.Event() sno = 1

def stop():
global dfl
stop_flag.
set() dfl
= True
graph()

stop_button = Button(output_window, text="Stop", font=("Arial 23 bold"),
command=stop, bg="purple")
stop_button.pack()
output_text = Text(output_window,
wrap="none")
output_text.pack(fill="both",
expand=True) try:
```

```
while not stop_flag.is_set():
now = datetime.datetime.now()
s = (str(now.day) + '/' + str(now.month) + '/' + str(now.year) + '
') line = ser.readline().decode().strip()

print(line)
data =
line.split(',')
if len(data) ==
2:

temperature, sound_level = data
td.append(float(temperature))
sd.append(float(sound_level))

freq = float(round(10 ** (round(float(sound_level)) / 10)))
fd.append(float(freq))

t.write(str(now.hour) + 'hrs' + ' ' + str(now.minute) + 'min' +
' ' + str(now.second) + 'sec' + " " + temperature + '\n')

f.write(str(now.hour) + 'hrs' + ' ' + str(now.minute) + 'min' +
' ' + str(now.second) + 'sec' + " " + sound_level + " " +
"frequency(Hz)" + str(freq) + '\n')

message = str(sno) + '. ' + str(now.hour) + 'hrs' + ' ' +
str(now.minute) + 'min' + ' ' + str(now.second) + 'sec' + " temp c" +
temperature + " sound.lvl dB" + sound_level + " frequency:" +
str(freq)

tid.append(sn
o-1) sno += 1

update_output(output_text,
message)
output_window.update()
time.sleep(1)

except Exception:
print("Stopped"
) finally:

t.close()
f.close()
```

```
def update_output(text_widget, message):

text_widget.insert("end", message + "\n")

text_widget.see("end")

def notice():

output_window = Toplevel()

output_window.title("Output Window")

threading.Thread(target=ot, args=(output_window,)).start()

notice()
```

For full code reference:
https://innowcrew.wordpress.com/2023/11/25/python- code-prediction-of-aquatic-species-behavior-in-response-to-anthropogenic- stressors-using-arduino/